



## **MERIDIONAL OVERTURNING STREAMFUNCTIONS AND FRESHWATER TRANSPORTS OF THE GLOBAL OCEAN**

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The meridional overturning circulation for the Atlantic, Pacific and Indian Oceans is computed from absolute geostrophic velocity estimates based on hydrographic data and from climatological Ekman transports. The Atlantic overturn includes the expected North Atlantic Deep Water formation (including Labrador Sea Water and Nordic Sea Overflow Water), with an amplitude of about 18 Sv through most of the Atlantic and error of order 3-5 Sv. The Lower Circumpolar Deep Water (Antarctic Bottom Water) flows north with about 8 Sv of upwelling and southward return in the South Atlantic, and 6 Sv extending to and upwelling in the North Atlantic. The northward flow of 8 Sv in the upper layer in the Atlantic (sea surface through the Antarctic Intermediate Water) is transformed to lower density in the tropics before losing buoyancy in the Gulf Stream and North Atlantic Current. The Pacific overturning streamfunction includes 10 Sv of Lower Circumpolar Deep Water flowing north into the South Pacific to upwell and return southward as Pacific Deep Water, and a North Pacific Intermediate Water cell of 2 Sv. For global southern hemisphere overturn across 30°S, the overturning is separated into a deep and a shallow overturning cell. In the deep cell, 22 to 27 Sv of deep water flows southward and returns northward as bottom water. In the shallow cell, 9 Sv flows southward at low density and returns northward just above the intermediate water density. In all three oceans, the tropics appear to dominate upwelling across isopycnals, including the migration of the deepest waters upwards to the thermocline in the Indian and Pacific. Estimated diffusivities associated with this tropical upwelling are the same order of magnitude in all three oceans.

The global total freshwater transports from this calculation show an equatorward transport of about 0.5 Sv from the Southern Ocean and 0.5 from the Arctic Ocean. The shallow subtropical gyre ventilation in each ocean carries saline water poleward and returns fresher water equatorward, with a magnitude of about 0.1 Sv. North Pacific Intermediate Water formation carries about the same amount of freshwater even though the net mass transport involved is much smaller than that of the shallow gyre transport. Labrador Sea Water and North Atlantic Deep Water formation carry 0.2 and 0.3 Sv equatorward.